Manual for magnetodielectric experiment in NHMFL

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Abstract

This manual is for the user of NHMFL optical experiment. The focus here is on the details that are easy to forget but critial for the running of experiments. The readers are assumed to have an good idea about the safty issues and the general idea about the experiments.

CONTENTS

PREFACE

We have suffered so much from not having a good manual in the magnet lab. Hopefully this manual will help us on our experiment in NHMFL. We should accumulate our knowledge by adding more information into this manual so that not only newbies can have a good starting point, but also the more experienced personnel can have a more systematic view.

Part I

Visible magnetodielectric experiment

Chapter 1

Equipment description and specificati

1.1 Light sources

1.1.1 Neon source

Ne source has sharp lines at 693 nm and 703 nm, which can be used for calibration.

(add real spectrm next time)

1.1.2 Mercury source

Hg lamp has 546.2 nm, 577.11 nm and 579.22 nm, which can also be used for calibration.

(We need to show some spectrum here.)

1.1.3 Xenon source

Wavelength range: from 200 nm to 2000 nm. It is normally used for short wavelength range below 500 nm.

Xenon source is susceptible to magnetic field. We need to make sure that it is far away from the magnetic field.

1.1.4 Tungsten Halogen source

Wavelength range: from 400 nm to 2500 nm.

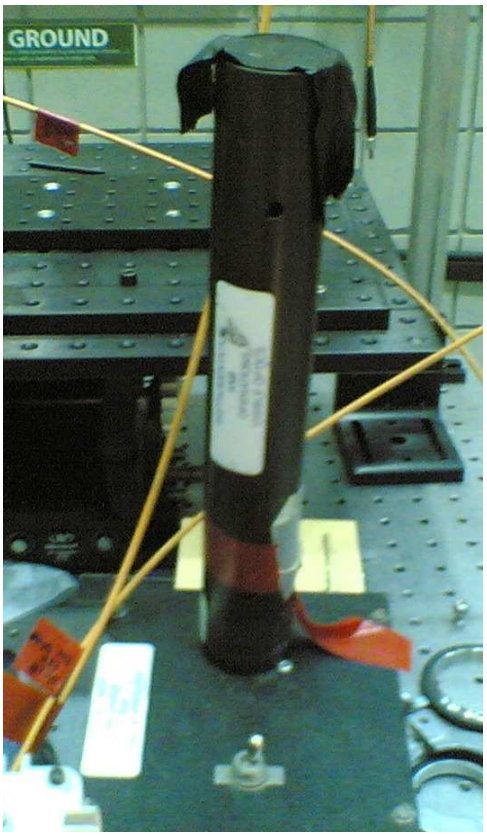


Figure 1.1: (Picture of Ne source.)

1.2 Detectors

Both detector must be pumped and cooled by liquid nitrogen.

1.2.1 CCD (charge coupled device) detector

Range: 300-1080 nm, mechanical shutter.

Exposure time should be larger than 2 seconds because the mechanical shutter is not precise.

Saturation: 5e5.

The temperature is monitored by the controller box. When the temperature is stabilized, the LED will become green, then the detector can operate effectively.

1.2.2 InGaAs detector

Range (nm): 1000 – 1600

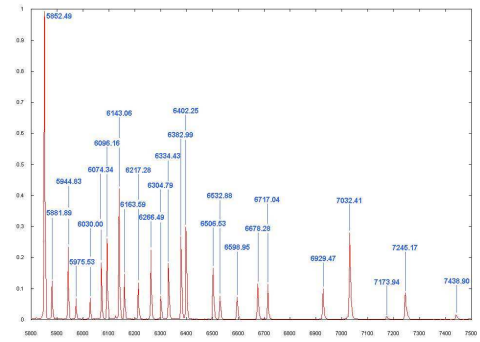


Figure 1.2: (Neon atom spectrum.)

Figure 1.3: (Picture of Xe source.)

Exposure time should be smaller than 5 seconds.

Saturation value: 6.5e4

The temperature is shown by the software, it has to be stabilized before data acquisition.

The coarse alignment of the InGaAs detector starts from removing InGaAs detector and looking into the hole using the wavelength 633. Then adjust the x-y-z stage of the input fiber.

Sometimes the detector needs to be rebooted by switching the power supply off and back on. When the InGaAs intensity is strangely low or when the software can not initialized InGaAs detector, this turning on and off may help.

Red fiber: 370 nm to 2000 nm.

Blue fiber: 300 nm to 700 nm.

Both fibers have minimum at around 950 nm.

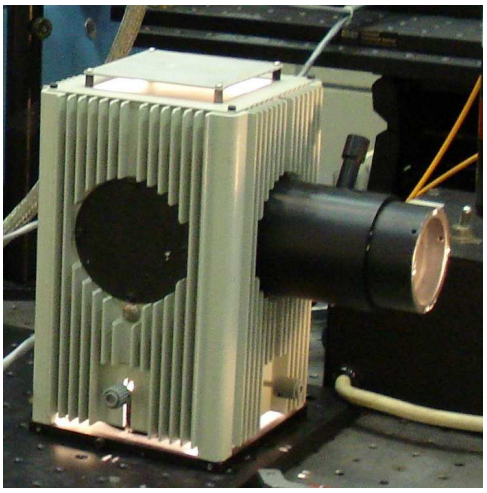


Figure 1.4: (Picuture of W source.)

1.3 Spectrometer

1.3.1 McPherson 2061A

Wavelength Range (nm): 185 to 78um

Spectral Resolution (nm): 0.015

Focal Length (mm): 1,000

Scanning: Available

Array Detectors: Available

Imaging: Available

Vacuum: Available

Ultra High Vacuum: no

1.4 Gratings

Normally, two kinds of gratings are used: 150 g/mm (blaze wavelength 800 nm) and 600 g/mm (blaze wavelength 400 nm). The range that the grating works should be above 1/2 blaze wavelength. The 150 g/mm grating gives much more intensity than the 600 g/mm (maybe 10 times). To switch the grating, we need to open the spectrometer and flip the grating.

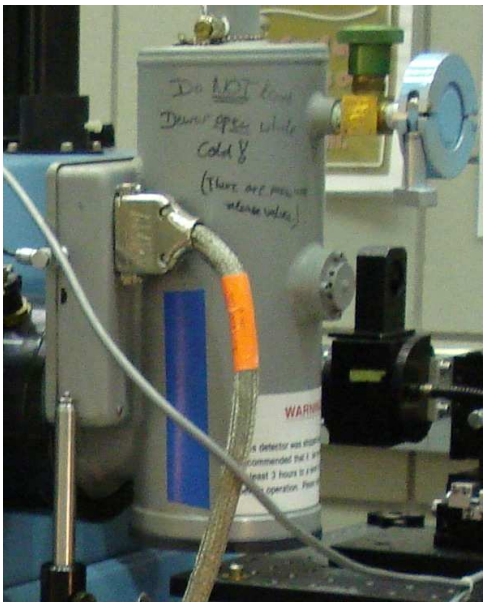


Figure 1.5: (The picture of CCD detector.)

1.5 Temperature controller

1.5.1 Sensor

The sensor is X10904.

1.5.2 Lakeshore 340 temperature controller

The calibration curve should correspond to X10904, which the sensor we have in the probe. For example, at 4 K, the resistance is 4.7 kΩ.

1.5.3 Cryocon 62 resistance bridge

Cryocon resistance bridge also works as a temperature controller. However, the software control is not ready yet.

1.5.4 Breakout box

The break out box is used to connect the temperature controller to the probe. The left four connectors are for the temperature measurement the right two are for the heater (if Lakeshore 340 is used, the other side goes to "high" and "low").

Figure 1.6: (Picture of InGaAs detector.)

For reflectance probe, temperature sensor goes to 1,2,3,4, and heater goes to 5,6. For transmittance probe, temperature sensor goes to 3,4,5,6 and heater goes to 1,2.

1.6 CRYOSTAT

Cryostat consists of vacuum jacket, nitrogen jacket and helium dewar. The vacuum jacket should be pumped before the experiment week. The nitrogen jacket should be filled once a day. The helium dewar should be filled once a day if the probe is not pulled out very frequently.

1.6.1 NITROGEN TRANSFER

The nitrogen transfer is done by connecting the liquid nitrogen LN Dewar to the one (out of three) of the release valve of the LN jacked using a rubber hose. The other

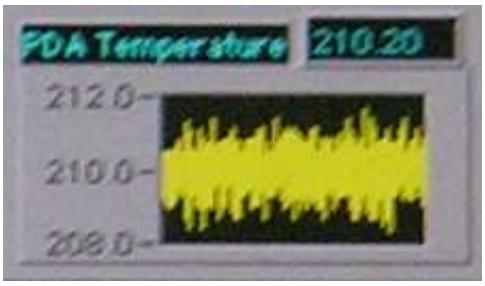


Figure 1.7: (Temperature monitor in the software for the InGaAs detector.)

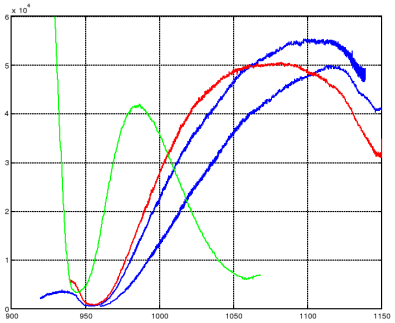


Figure 1.8: (Example of signal showing the minimum of ther fibers around 950 nm. Green curve is from CCD detector. The other curves are from InGaAs detector. The red fibers are used.)

two release valve should be removed during the transfer. After the transfer, all three valve should be put back.

1.6.2 Helium transfer

The liquid helium can be transferred using a long transfer line when the He Dewar is on the ground. The He recycle bellow (as shown in 1.13) should be disconnected. After transfer, the bellow should be reconnected. The He level of the cryostat and the Dewar can both be measured using the gauge on the wall. The cryostat corresponds to "Janis" on the gauge.

1.7 Computers

There are two computers for the experiment. The data computer is called data1mac.magnet.fsu.edu. The experiment computer is called opticsmac (this

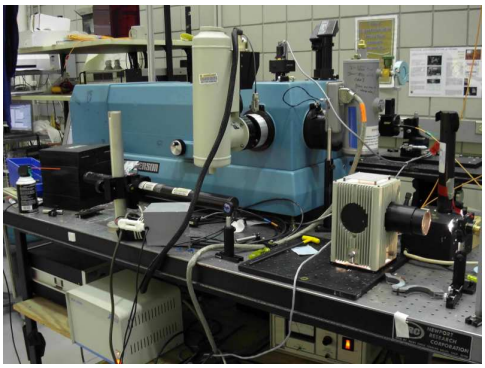


Figure 1.9: (Picture of spectrometer.)

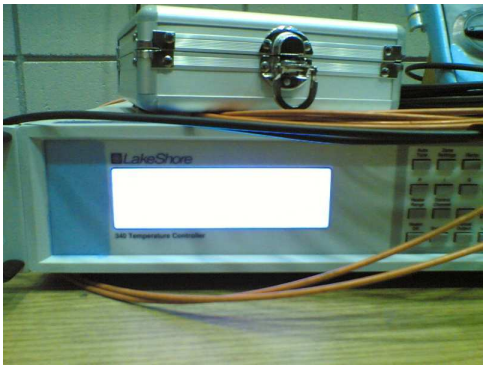


Figure 1.10: (Picture of Lakeshore temperature controller.)

is the one that controls the spectrometer).

It is always efficient if one can look at the data from the data computer while the other computer is running experiment. In order to do this, we need to connect the data computer to the experiment computer to download the data.

The following steps should be followed:

from the main menu, go->connect to sever->browse->opmd->opticsmac->login using the account "guest" (or using the account "user" with password nhmfl).

1.8 Probe

1.8.1 Fibers

The probe has two build-in pairs of fibers: uv-vis (red) and vis-ir (red). The red fibers cover most of the wavelength range (370-2000 nm), while the blue fibers are

Figure 1.11: (Picture of cryocon resistance bridge.)

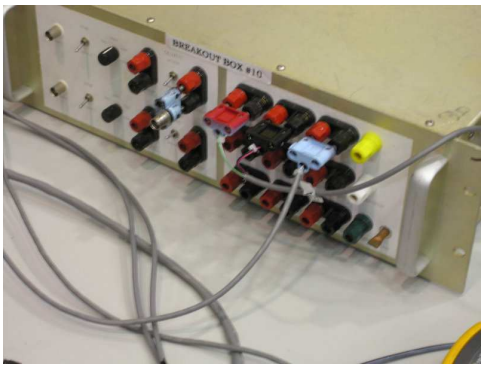


Figure 1.12: (Pciture of breakout box.)

good only for short wavelength range (300-700 nm). The shorter fibers are for the collection of reflected light and the longer ones are for the incident light.

1.8.2 Sample mounting

Sample holder are supposed to be glued on the copper plate of the probe head using super glue.

There are two rotation mechanism in the probe: one is to adjust the z position of the sample, the other is the rotate the sample (this one has huge backlash and is not precise at all). The fibers are marked as A, B, C or D in the probe. They are also marked as vis-uv1, vis-uv2, vis-ir1 or vis-ir2, the correspondence should be checked before the experiment.

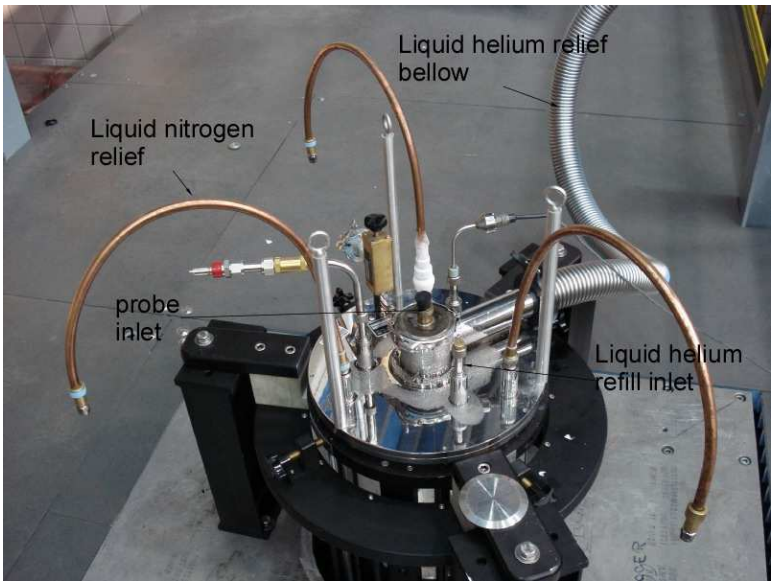


Figure 1.13: (Picture of the cryostat.)

1.8.3 Stopper

Probe does not go all the way down to the cryostat. Instead, it need to be positions correctly in order to put the sample in the center of the field. In principle, at the center of the field, the magnetic force on the sample is zero.

The position of the stopper of the probe is critical to prevent too much magnetic force on the sample.

As shown in 1.18, the distance L4 is calculated from L (from brass part to sample), L1, from center of to the edge of the magnet, L2 (from the edge of the magnet to the surface of the deck) and L3 (from the surface of the deck to the fitting of the cryostat. L, L3 are measured by the experimenter, while L1 and L2 are giving by the chart on the wall of the cell.

1.9 Magnetic field

The magnetic field is almost constant in the range +/- 2 cm range from the center. The total deviation is less than 0.5 T as shown in Fig. 1.19.

The calibration of magnetic field is a polynomial $B=f(I)=aI+b*I^3$. The coefficient a and b are posted on the wall.

Figure 1.14: (Picture of experiment computer.)

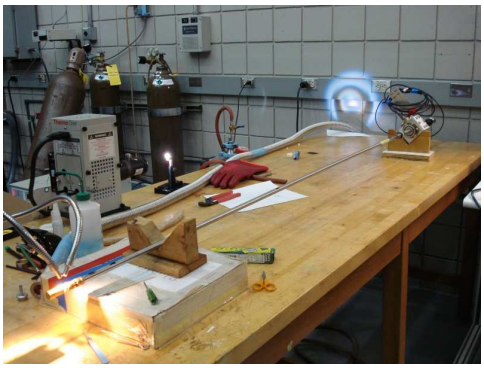


Figure 1.15: (Picture of the probe.)

1.10 POLARIZER

We have made rectangular shaped polarizer for the probe, with both $\vec{E}$ field parallel and perpendicular to the longer side.

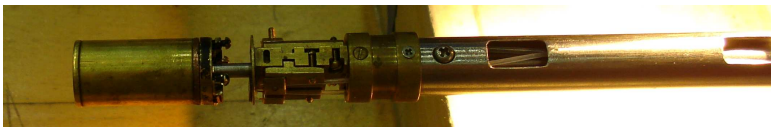


Figure 1.16: (Sample mount part of the probe.)

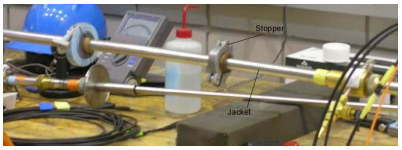


Figure 1.17: (Picture of the probe with the jacket and the stopper.)

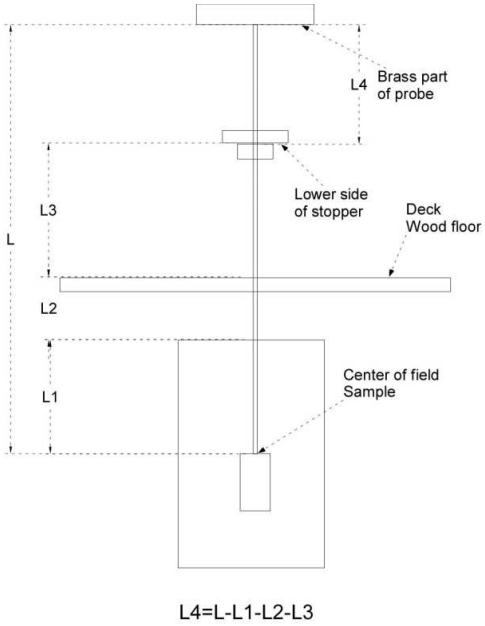


Figure 1.18: (Illustration of calculation of the probe stopper.)

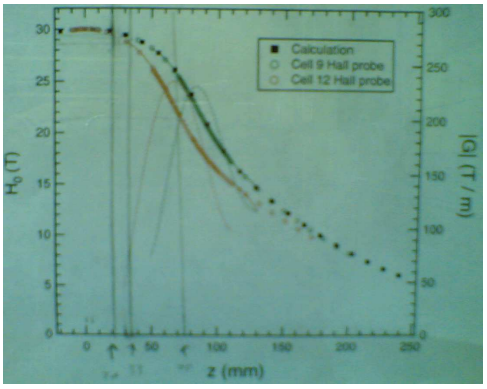
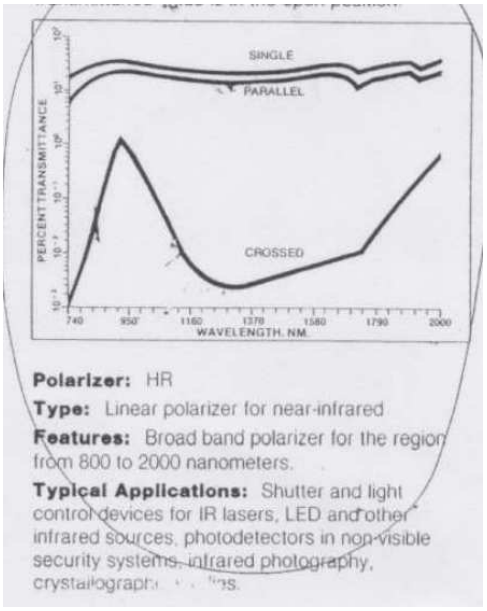
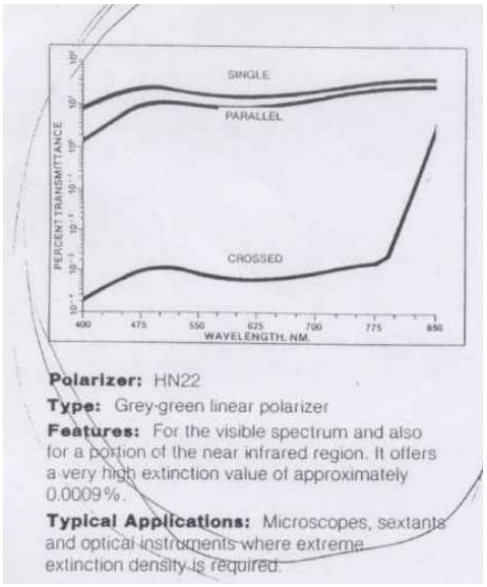


Figure 1.19: (Calibration of magnet in cell 9 and cell 12.)



Polarizer: HR
Type: Linear polarizer for near-infrared
Features: Broad band polarizer for the region from 800 to 2000 nanometers.
Typical Applications: Shutter and light control devices for IR lasers, LED and other infrared sources, photodetectors in non-visible security systems, infrared photography, crystallograph[illegible]s.

Figure 1.20: (Transmittance of uv-vis polarizer.)



Polarizer: HN22
Type: Grey-green linear polarizer
Features: For the visible spectrum and also for a portion of the near infrared region. It offers a very high extinction value of approximately 0.0009%.
Typical Applications: Microscopes, sextants and optical instruments where extreme extinction density is required.

Figure 1.21: (Transmittance of ir-vis polarizer.)

CHAPTER 2

OPERATION

2.1 PREPARATION OF THE PROBE

Mount the sample holder

Align the samples with the fibers (only for reflectance probe)

Pump the probe with the jacket on

Add helium exchange gas (approximately 10 cm of the hose if the flow rate is 15).

2.2 FIBER ALIGNMENT

There are three micrometers on the xyz-stage to adjust the position of the input fiber. Normally x and z direction should be adjusted.

In several cases, we have to align the input fiber for the spectrometer. For example, switching the grating, switching the detector.

If CCD is used, one can see the alignment from the PDA image on the screen. If InGaAs is used, one has to tell the alignment from the intensity of the light collected by the detector.

Poor alignment not only reduces intensity, but also affects wavelength calibration. Therefore this is important if the merging of data between different center positions is critical.

Following are the sample numbers of the x and z micrometers.

Table 2.1: Sample setting for x and z mircrometer

grating		CCD	InGaAs
150	z	8.00	6.89
150	x	11.3	10.85
300	z	5.5	4.3
300	x	11.3	11.3

2.3 Main software

To start the software, one should launch the software "Labview", then open "NHMFL visible optics.vi".

Figure 2.1: (Picture of "stop" button.)

To stop and reboot the software, click "stop", then "quit". After that, click the red button on the upper left corner, then quit in the file menu.

2.4 Calibration of wavelength

Before starting any real measurements, the wavelength of the spectrometer should be calibrated.

Normally, there is a short red fiber just for the calibration.

For example: 150 g/mm using Ne source, one should follow the step:

goto 700 nm->expert setup->calibration->calibrate->accept->done.

During the calibration, the slit need to be closed. (Let's save spectra and show it here next time)

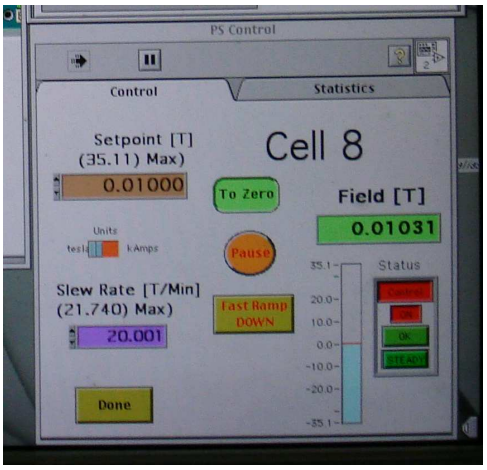


Figure 2.2: (Window for the magnetic field control.)

2.5 Magnetic field control

The magnetic field can be changed by the software once the cell has the control, in this case, the "set point" is enabled. Sometimes the software does not change the field in a sequence scan even when the user does have the control (the field can be changed manually by typing the numbers in the "set point"). If this happens, click "Done" button and run the window again. Then the problem is solved.

2.6 Temperature control

Figure 2.3: (Temperature control window in the software.)

Temperature control is possible if the Lakeshore 340 is used. In this case, the

temperature can be changed by typing the number in the "set point". The temperature control part sometime gets the whole program stuck. One should either wait or press the "" button in the window to solve the problem.

To set the temperature, one has to click on "configuration" button and set up the parameters. When you reach the desired temperature, wait at least 2 minutes in order to stabilized it.

2.7 Data acquisition

2.7.1 Single shot

In the "single shot" mode, one can take shot at certain condition (field, temperature). The data can be saved if the option is chosen.

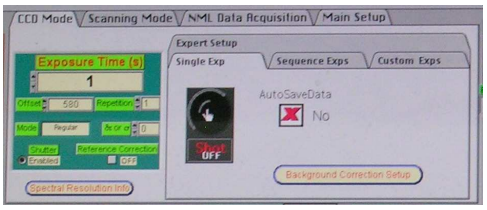


Figure 2.4: (Window for single shot mode.)

2.7.2 Sequence shot

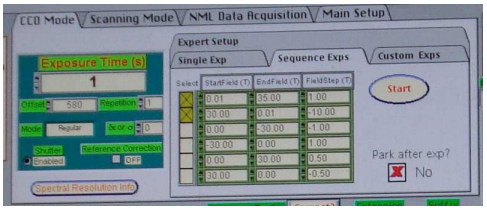


Figure 2.5: (window for sequence shot.)

The sequence shot mode is used if magnetic field is to be scanned. One can define sequence of field and let program run the scan automatically.

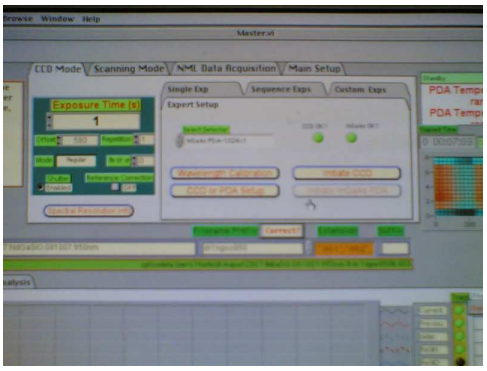


Figure 2.6: (The detector changing and initializing window in the software.)

2.8 SWITCHING DETECTORS

To switch the detector (CCD and InGaAs), one has to flip the mirror in the spectrometer and change the detector option in the software (in the expert setup mode). The detectors need also be initialized when switched (expert mode->initiate).

2.9 SWITCHING GRATINGS

Figure 2.7: (Window of gratting and center position setting.)

To switch the grating, one needs to open the spectrometer, either change the grating by another one or flipping the grating to use the other one inside. After this, one has to change the corresponding grating in the software. The current wavelength will be very different then the grating option is changed in the software. One needs to hit "goto" to get the wavelength wanted.

REMARK 1 *If one changes the grating in the spectrometer but doesn't change the setting in the software, the whole experiment setup will be ruined. In that case, one has to calibrate the wavelength manually by reading the wavelength number from the spectrometer.*

2.10 Switching sources

To switch the source, one just has to move the incident fiber.

Part II

Infrared magnetodielectric experiment

Appendix A

The First Appendix

Appendix B

Afterword